The handling mechanism is disposed in the vacuum chamber 311 of the vacuum casing 310 and includes a handling member pivotally supported by the first fixed member 381 and the base member 390 to be operative to handle wafers and other substrates in the vacuum chamber 311 of the vacuum casing 310.

While the sealing ring 153 has been described in the above as including an annular spring member 155 made of a metal wire in the form of a helical shape as shown in FIG. 2, the annular spring member 155 may be replaced by an annular spring member made of a metal plate in the form of an annular ring shape as shown in FIG. 3 according to the present invention.

As will be seen from FIG. 3, the sealing ring 153 of the first sealing unit 350 includes an annular resilient member 156 formed with an annular groove 156a, and an annular spring member 157 received in the annular groove 156a of the annular resilient member 156 and retained by the annular resilient member 156. The annular resilient member 156 of the sealing ring 153 has a peripheral portion 156b securely retained by the annular ledge 351d of the retaining member 351, and a sealing lip 156c integrally formed with the peripheral portion 156b of the annular resilient member 156 and radially inwardly extending from the peripheral portion 156b of the annular resilient member 156 to be held in contact with the outer cylindrical surface 340b of the center shaft 340. The sealing lip 156c of the annular resilient member 156 is made of a synthetic resin constituted by an ultra high molecular weight compound.

The annular resilient member 156 of the sealing ring 153 may have a flange portion 156d integrally formed with the peripheral portion 156b of the annular resilient member 156 and radially outwardly extending from the peripheral portion 156b of the annular resilient member 156. The flange portion 156d of the annular resilient member 156 is held in contact with the retaining member 351 of the first sealing unit 350 to hermetically seal the gap between the center shaft 340 and the retaining member 351 of the first sealing unit 350.

The annular spring member 157 of the sealing ring 153 is operative to impart a force to the sealing lip 156c of the annular resilient member 156 to ensure that the sealing lip 156c of the annular resilient member 156 is held in tight contact with the outer cylindrical surface 340b of the center shaft 340. The annular spring member 157 of the sealing ring 153 is made of a metal plate in the form of an annular ring shape and is of a channel-shaped cross-section taken on the plane perpendicular to the center axis passing therethrough. The annular spring member 157 thus constructed is generally called "cantilever spring".

Though the sealing ring 163 has been described in the above as including an

annular spring member 165 made of a metal wire in the form of a helical shape as shown in FIG. 2, the annular spring member 165 may be also replaced by an annular spring member made of a metal plate in the form of an annular ring shape as shown in FIG. 3 according to the present invention.

While the shaft sealing apparatus 300 has been described in the above as comprising a sleeve shaft 330 rotatably supported by the shaft housing 320 as shown in FIG. 7, the shaft sealing apparatus 300 may further comprise an intermediate shaft housing intervening between the shaft housing 320 and the sleeve shaft 330 according to the present invention. The intermediate shaft housing is axially movably supported by the shaft housing 320 and rotatably supports the sleeve shaft 330 to ensure that the sleeve shaft 330 is rotatable and axially movable with respect to the shaft housing 320. This fact leads to the fact that the second sealing unit 360 intervenes between the vacuum casing 310 and the sleeve shaft 330 to hermetically seal the gap between the vacuum casing 310 and the sleeve shaft 330 under a rotation and a linear motion of the sleeve shaft 330.

The following description will be directed to a method of assembling the shaft sealing apparatus 300 with reference to the drawing shown in FIG. 7. The method of assembling the shaft sealing apparatus 300 is performed through the steps including a preparing step and first to third installing steps as follows.

In the preparing step, the vacuum casing 310, the shaft housing 320, the sleeve shaft 330, the center shaft 340, the first bearing 359, and the second bearing 369 are prepared as a partially assembled unit. The constructions of the vacuum casing 310, the shaft housing 320, the sleeve shaft 330, the center shaft 340, the first bearing 359, and the second bearing 369 have been described in the above.

In the first installing step, the first sealing unit 350 constituted by the retaining member 351 and the sealing rings 153 securely retained by the retaining member 351 is installed in the annular ledge 330d of the shaft housing 330, and the second sealing unit 360 constituted by the retaining member 361 and the sealing rings 163 securely retained by the retaining member 361 is installed in the annular ledge 320d of the shaft housing 320. The constructions of the first and second sealing units 350 and 360 have been described in the above.

In the second installing step, the second fixed member 382 is installed on the first axial end 320a of the shaft housing 320, and the first fixed member 381 is installed on the first axial end 330a of the sleeve shaft 330. The second labyrinth seal unit 372 is then installed between the shaft housing 320 and the sleeve shaft 330 to be exposed to the vacuum chamber 311 of the vacuum casing 310. The constructions of the first and second fixed members 381 and 382, and the second

labyrinth seal unit 372 have been described in the above.

In the third installing step, the base member 390 is installed on the first axial end 340a of the center shaft 340. The first labyrinth seal unit 371 is then installed between the sleeve shaft 330 and the center shaft 340 to be exposed to the vacuum chamber 311 of the vacuum casing 310. The constructions of the base member 390 and the first labyrinth seal unit 371 have been described in the above. The shaft sealing apparatus 300 is then assembled as shown in FIG. 7.

As will be seen from the foregoing description, the fact that the outer cylindrical surface of the driving shaft is smaller in surface roughness Ra than 0.1 μ m and larger in Vickers hardness Hv than 650 leads to the fact that the third embodiment of the shaft sealing apparatus according to the present invention makes it possible (1) to be excellent in characteristic to seal the gaps between the driving shaft and other parts around the driving shaft within a tolerance (less than 1×10^{-9} Pa m^3/s). In addition, the fact that the sealing lip of the sealing ring is made of a synthetic resin constituted by an ultra high molecular weight compound leads to the fact that the third embodiment of the shaft sealing apparatus according to the present invention makes it possible (2) to check the flow of gas. Further, the fact that each of the sealing units is installed in the shaft sealing apparatus separately leads to the fact that the third embodiment of the shaft sealing apparatus according to the present invention makes it possible (3) to be simple in construction, (4) to be reduced in size, (5) to be reduced in production cost, (6) to be assembled with facility, (7) to eliminate the need of centering of the sealing unit, and (8) to prevent the sealing lip from breaking. Further, the fact that each of the labyrinth seal units is installed in the shaft sealing apparatus leads to the fact that the third embodiment of the shaft sealing apparatus according to the present invention makes it possible (9) to prevent dust, oil and gas from passing through the interstice of the labyrinth seal unit. Further, the fact that each of the base member and the first fixed member collectively constitute the first labyrinth seal unit, and the first and second fixed members collectively constitute the second labyrinth seal unit leads to the fact that the third embodiment of the shaft sealing apparatus according to the present invention makes it possible (10) to be reduced in parts count, and (11) to be reduced in size.